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ARTICLE

US Infant Mortality Trends Attributable to Accidental Suffocation and Strangulation in Bed From 1984 Through 2004: Are Rates Increasing?

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What's Known on This Subject

Several recent studies have examined trends and characteristics of infant deaths attributed to injury, but these studies were either limited to postneonatal deaths or did not specifically examine infant injury attributed to ASSB.

What This Study Adds

Infant mortality rates attributable to ASSB have quadrupled in the last 2 decades, with the most dramatic increase occurring after 1996. The reason for this increase is unknown, but black male infants <4 months of age are disproportionately affected.

ABSTRACT

OBJECTIVE. Accidental suffocation and strangulation in bed, a subgroup of sudden, unexpected infant deaths, is a leading mechanism of injury-related infant deaths. We explored trends and characteristics of these potentially preventable deaths.

METHODS. In this descriptive study, we analyzed US infant mortality data from 1984 through 2004. To explore trends in accidental suffocation and strangulation in bed and other sudden, unexpected infant deaths, we calculated cause-specific infant mortality rates and estimated proportionate mortality. Sudden, unexpected infant death was defined as a combination of all deaths attributed to accidental suffocation and strangulation in bed, sudden infant death syndrome, and unknown causes. Finally, we examined factors that were reported as contributing to these accidental suffocation and strangulation in bed deaths.

RESULTS. Between 1984 and 2004, infant mortality rates attributed to accidental suffocation and strangulation in bed increased from 2.8 to 12.5 deaths per 100 000 live births. These rates remained relatively stagnant between 1984 and 1992 and increased between 1992 and 2004; the most dramatic increase occurred between 1996 and 2004 (14% average annual increase). In contrast, total sudden, unexpected infant death rates remained stagnant between 1996 and 2004, whereas the proportion of deaths attributed to sudden infant death syndrome declined and to unknown cause increased. Black male infants <4 months of age were disproportionately affected by accidental suffocation and strangulation in bed. Beds, cribs, and couches were reported as places where deaths attributed to accidental suffocation and strangulation in bed occurred.

CONCLUSIONS. Infant mortality rates attributable to accidental suffocation and strangulation in bed have quadrupled since 1984. The reason for this increase is unknown. Prevention efforts should target those at highest risk and focus on helping parents and caregivers provide safer sleep environments. *Pediatrics* 2009;123:533–539

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Key Words
accidental suffocation, sudden unexpected infant death, sudden infant death syndrome, SIDS, infant mortality, classification, reporting, death certification, vital statistics, death-scene investigation, unintentional injury

Abbreviations
ASSB—accidental suffocation and strangulation in bed
SUID—sudden, unexpected infant death
SIDS—sudden infant death syndrome
CDC—Centers for Disease Control and Prevention
SUIDIRF—Sudden, Unexplained Infant Death Investigation Report Form
NCHS—National Center for Health Statistics
ICD-9—*International Classification of Diseases, Ninth Revision*
ICD-10—*International Statistical Classification of Diseases and Related Health Problems, Tenth Revision*
CI—confidence interval

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ACCIDENTAL SUFFOCATION AND strangulation in bed (ASSB), a subgroup of sudden, unexpected infant deaths (SUIDs), is a leading category of injury-related infant deaths. Although evidence suggests that the rate of ASSB is increasing,[1] ASSB deaths are potentially preventable. ASSB includes suffocation by (1) soft bedding, pillow, or waterbed mattress, (2) overlaying or rolling on top of or against infant while sleeping, or (3) wedging and entrapment of an infant between 2 objects such as a mattress and wall, bed frame, or furniture; and strangulation by asphyxiation, such as when an infant's head and neck become caught between crib railings. ASSB deaths share many of the same sociodemographic characteristics as sudden infant death syndrome (SIDS) and cause unknown deaths.[1]

A comprehensive death-scene investigation is critical to classify SUIDs deaths accurately and to help distinguish ASSB deaths from SIDS deaths. Autopsy findings alone often cannot differentiate between ASSB and SIDS because

pathophysiological findings that can distinguish an ASSB death from a SIDS death are not always evident.[2,3] Recent evidence showed that the decline in SIDS, from 1998 through 2001, was offset by an increase in ASSB and cause unknown deaths, suggesting that there has been a change in the way these SUIDs are classified and reported.[1,8] Researchers need improved scientific knowledge and understanding about the epidemiology of ASSB deaths so that preventive interventions can be effectively designed.

Prevention of ASSB deaths can have an important effect on reducing the overall infant mortality rate. Injuries and injury-related deaths can be prevented by ensuring that all infants live in a safe environment; therefore, public health professionals must first know what constitutes a dangerous environment and second, how to best educate caregivers about providing safe infant environments.

Although several recent studies have examined trends and characteristics of infant deaths attributed to injury, these studies were either limited to postneonatal deaths or did not specifically examine ASSB deaths.[4–8] Earlier descriptive studies[5] that examined trends in infant ASSB deaths were conducted before the release of the national SUID death-scene guidelines in 1996 or were limited to deaths reported to the US Consumer Product Safety Commission. The Centers for Disease Control and Prevention's (CDC's) 1996 guidelines for death-scene investigation and Sudden, Unexplained Infant Death Investigation Report Form (SUIDIRF)[9] were part of an effort to standardize and improve the quality of data collection at infant death-scene investigations and promote a more informed assignment of cause-of-death classification.

In this study, we explored trends in infant deaths attributed to ASSB since 1984, before and after the release of the 1996 national guidelines, and assessed how the trend indicating fewer SIDS deaths might be explained by the trends showing increases in ASSB and cause unknown deaths. In addition, we evaluated demographic characteristics of infants who reportedly died of ASSB and examined the primary circumstances and factors that were reported as contributing to these deaths. This analysis focused on improving understanding of the epidemiology of these deaths and thereby strengthening our ability to design more effective prevention strategies.

METHODS

For this population-based, descriptive study, we calculated and analyzed cause-specific infant mortality rates for ASSB, SIDS, and cause unknown and estimated proportionate mortality for 1984–2004 using mortality data from the Compressed Mortality File accessed via CDC WONDER (http://wonder.cdc.gov). The Compressed Mortality File is derived from the National Vital Statistics System and is compiled by the CDC's National Center for Health Statistics (NCHS). Non-US residents were excluded.

We defined the cause-specific infant mortality rate as the number of deaths attributed to a specific cause in a calendar year per 100 000 live births for the same year.[10] Codes for cause of death were defined according to the *International Classification of Diseases, Ninth Revision* (ICD-9) for 1984–1998, and the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* (ICD-10) for 1999–2004.[11,12] We used guidelines from the NCHS to determine the comparability between ICD-9 and ICD-10 codes.[13] We defined cause of death by using the following ICD-9 and ICD-10 codes: ASSB (E913.0; W75), SIDS (798.0; R95), and unknown cause, (799.9; R99) based on the underlying cause of death. SUID was the combination of ASSB, SIDS, and cause unknown deaths.

We used Poisson regression to determine the average annual percent change in cause-specific mortality rates by using the number of deaths as the response variable with a population offset and added years to the model as an independent variable. Rate ratios generated from regression models were subtracted from 1 and then multiplied by 100 to estimate the average annual percent changes. *z* values and corresponding 95% confidence intervals (CIs) were used to assess the precision of the percent changes.

The change from ICD-9 to ICD-10 in 1999 resulted in comparability problems for many causes of death, including those in our analysis (eg, both ASSB and SIDS were more likely to be selected as the underlying cause of death under ICD-10 than under ICD-9). These comparability problems result in discontinuities in the trends for these causes. We accounted for this comparability issue in our calculations of the annual percent change by creating a dummy variable in our regression models (1 = ICD-10 years, 0 = ICD-9 years) to control for the discontinuity caused by changing revisions.

We defined proportionate ASSB mortality as the number of deaths attributable to ASSB divided by the total number of SUIDs multiplied by 100. We also calculated the proportionate mortality for SIDS and unknown causes. To improve our understanding of the demographic characteristics of infants whose deaths were attributed to ASSB, we compared ASSB percent distributions by age at death, month of death, and day of death using the 2002–2004 US Multiple Cause of Death Data file. We combined these most recent years of data available to provide more stable rates because annual random variations in subcategories with small numbers can produce wide fluctuations in rates.

Finally, using 2003 and 2004 US mortality files, we examined written text from the cause-of-death section of the death certificate for all ASSB-coded deaths, namely the causes of death and the description of how the injury occurred as entered by the certifier. NCHS has been electronically capturing these data since 2003, and this additional information may provide broader and more detailed information about the circumstances and factors associated with the infant death. More specifically, we used this written text to categorize ASSB deaths by the mechanism responsible for the death (eg, overlay, wedging or entrapment, suffocation by soft bedding, and strangulation) and then determined the frequency of these categories. In addition, we categorized deaths by the type of sleep surface where the death was

TABLE 1 Total and Cause-Specific SUID Mortality Rates and Proportionate SUID Mortality, United States, 1984–2004

	Cause-Specific Mortality Rate per 100 000 Live Births				Distribution of SUIDs According to Specified Cause, %			Total No. of SUIDs
Year	ASSB	SIDS	UNK	Total SUID	ASSB	SIDS	UNK	
1984	2.8	142.9	14.6	160.3	1.8	89.1	9.1	5885
1985	3.0	141.3	13.8	158.1	1.9	89.4	8.7	5945
1986	3.1	140.5	16.9	160.5	2.0	87.5	10.5	6029
1987	3.5	137.3	20.7	161.5	2.1	85.0	12.8	6152
1988	2.9	140.1	22.7	165.7	1.7	84.6	13.7	6476
1989	3.6	139.4	21.9	164.9	2.2	84.5	13.3	6665
1990	3.4	130.3	20.9	154.6	2.2	84.3	13.5	6428
1991	3.6	130.1	19.4	153.1	2.4	85.0	12.6	6293
1992	3.1	120.3	19.7	143.1	2.2	84.1	13.7	5817
1993	3.8	116.7	21.9	142.4	2.7	82.0	15.4	5697
1994	4.1	103.0	18.7	125.9	3.3	81.9	14.9	4976
1995	3.7	87.1	22.3	113.1	3.3	77.0	19.7	4412
1996	3.9	78.4	18.7	100.9	3.8	77.6	18.5	3928
1997	4.4	77.1	17.8	99.2	4.4	77.7	17.9	3851
1998	4.7	71.6	18.2	94.5	4.9	75.8	19.3	3724
1999	6.4	66.9	20.5	93.9	6.9	71.3	21.9	3716
2000	6.6	62.2	25.7	94.4	6.9	65.8	27.2	3833
2001	9.7	55.5	29.4	94.6	10.2	58.7	31.1	3807
2002	10.6	57.1	26.9	94.5	11.2	60.4	28.4	3801
2003	10.2	52.9	26.6	89.7	11.4	58.9	29.7	3669
2004	12.5	54.6	25.3	92.4	13.5	59.1	27.4	3798

Total SUID is defined as a combination of all deaths attributed to ASSB, SIDS, and unknown (UNK).

reported to have occurred (eg, adult bed, crib, sofa) and by whether bed sharing or cosleeping was reported.

We limited our assessment of racial and ethnic disparities to black and white infants because misreporting of decedent's racial and ethnic identity to groups on the death certificate is a concern.[14] Because this analysis used existing deidentified NCHS data, it was determined to be research not involving human subjects, and therefore exempt from human subjects review. Data were analyzed by using Stata 9 statistical software (Stata Corporation, College Station, TX).

RESULTS

In Table 1 we assess the overall and cause-specific SUID mortality trend, as well as the distribution of SUIDs by cause of death. The trend in the overall total SUID rate mirrors the trend in the SIDS rate until 1998 when the total SUID rate begins to become stagnant and remain stagnant through 2004, the latest year that data were available. Between 1984 and 2004, ASSB infant mortality rates more than quadrupled, from 2.8 to 12.5 deaths per 100 000 live births (Table 1 and Fig 1). This represents 513 infant deaths attributed to ASSB in 2004 compared with 103 in 1984. Between 1984 and 1992, infant mortality attributed to ASSB remained relatively stagnant ranging from 2.8 to 3.6 deaths per 100 000 live births. Then, between 1992 and 1996, the number of infant deaths attributed to ASSB began to increase. This increase continued through 2004, but was more dramatic after 1996 and onward. Of note, each of the cause-specific rates and the number of deaths decrease in 2003. In 2004, only the rate for ASSB returns to a higher level than previous years. In contrast, the proportion of deaths attributed to ASSB and cause unknown increased in 2003 compared with 2004, whereas the proportion of SIDS deaths during this time declined. In 2004, the proportion of deaths attributed to ASSB and SIDS deaths both increased, whereas unknown cause declined.

Deaths attributed to cause unknown increased from 1984 through 1986 and then remained relatively stagnant from 1987 through 1999. Rates increased from a range of 17.8 to 22.7 deaths per 100 000 live births during 1987–1999 to 25.3 to 29.4 during 2000–2004. Deaths attributed to SIDS declined from 1984 through 2000 and then remain stagnant from 2001 through 2004.

To assess the rate of change in cause-specific mortality rates, we calculated the average annual percent change from 1996 through 2004. Although there has been a statistically significant average annual percent increase in ASSB deaths of 14% (95% CI: 11% to 16%; $P < .05$), the total SUID rates have remained fairly stagnant (average annual percent change: −1% [95% CI: −2% to 0%]; $P < .05$). The average annual percent of deaths increased 2% (95% CI: 1% to 3%; $P < .05$) for cause unknown deaths and declined 4% (95% CI: −5% to −3%; $P < .05$) for deaths attributable to SIDS.

In our assessment of proportionate mortality, the proportion of SUID deaths attributed to ASSB remained fairly stable, ranging from 1.8% to 2.4% for 1984 through 1992 (Table 1 and Fig 2). However, this proportion began to increase in 1993 and continued to do so through 2004, increasing fivefold from 2.7% in 1993 to 13.5% in 2004. Although the combined SUID rate remained stable from 1997 through 2004, the proportion of SUID deaths attributed to ASSB more than tripled, from 4.4% in 1997 to 13.5% in 2004 and the proportion of deaths attributed to SIDS declined, from 77.7% in

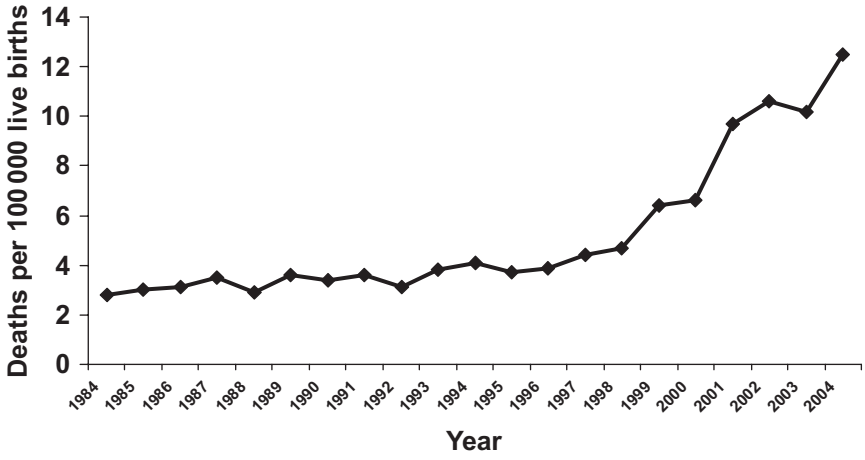

FIGURE 1
Infant mortality rates per 100 000 live births attributable of ASSB, United States, 1984–2004.

1997 to 59.1% in 2004. During the same time, the proportion of deaths attributed to unknown cause increased until 2000, but between 2000 and 2004, the proportion of deaths are nearly identical with periodic rises and falls in that time period. Thus, for deaths of unknown cause, there was no indication of an increasing or decreasing trend during 2000 through 2004, although the proportion of deaths was higher than any previous years.

Infants whose deaths were attributed to ASSB during 2002–2004 had some noteworthy characteristics. For example, black infants were disproportionately affected (27.3 vs 8.5 deaths per 100 000 live births for blacks and whites, respectively), as were male infants (12.5 vs 9.6 deaths per 100 000 live births for males and females, respectively). Table 2 shows ASSB percent distributions by age at death, month of death, and day of death. Infants 0 to 3 months old (especially those 1 month old) had the highest mortality attributable to ASSB. Whereas there was no seasonal variation detected for ASSB mortality, the day of week pattern was more variable. ASSB mortality was from 3 to 6 times higher on Mondays and Wednesdays than other days of the week, and mortality on Sundays and Tuesdays was double that of Thursdays and Fridays.

Review of the 2003–2004 death certificate written text revealed that overlay was the most frequently reported circumstance for infant ASSB deaths (33.8%), followed by suffocation by bedding materials (13.8%) and wedging or entrapment (14.2%; Table 3). However,

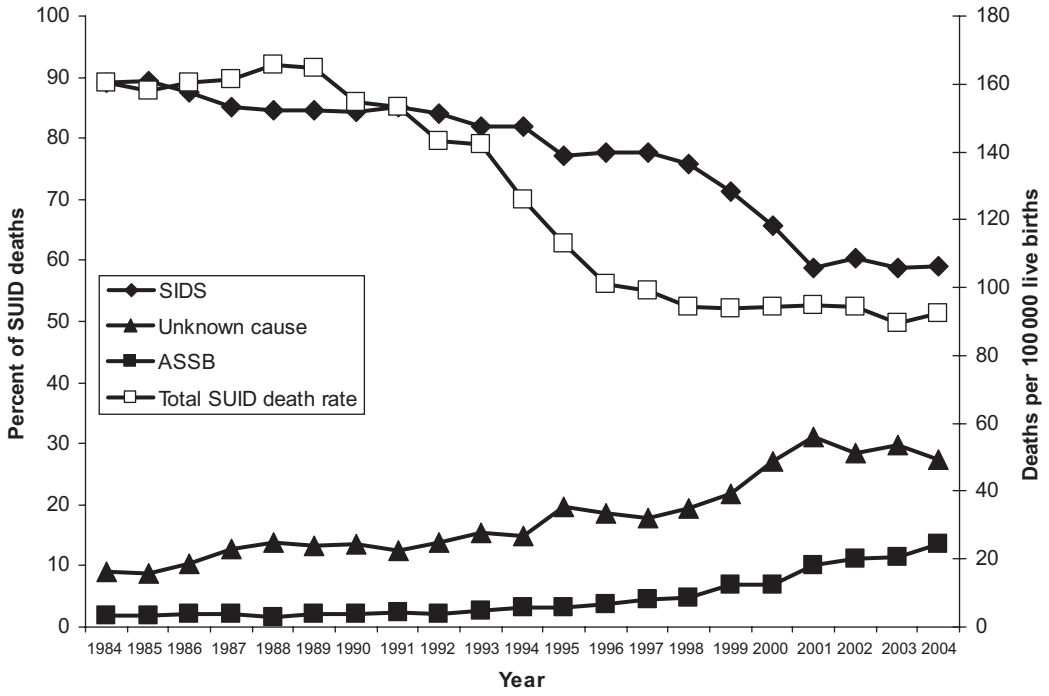

FIGURE 2
Proportionate SUID mortality attributable to ASSB, SIDS, and unknown cause (primary y-axis) and total SUID mortality rate (secondary y-axis), United States, 1984–2004.

TABLE 2 ASSB Percent Distributions According to Age at Death, Month of Death, and Day of Death, United States, 2002–2004

Selected Characteristic	*n*	%
Age at death, mo		
0	200	14.7
1	334	24.6
2	276	20.4
3	179	13.2
4	104	7.7
5	81	6.0
6	45	3.3
7	56	4.1
8	32	2.4
9	23	1.7
10	12	0.9
11	14	1.0
Day of week at death		
Sunday	144	10.6
Monday	454	33.5
Tuesday	152	11.2
Wednesday	348	25.7
Thursday	69	5.1
Friday	71	5.2
Saturday	116	8.6
Month of death		
January	135	10.0
February	97	7.2
March	108	8.0
April	118	8.7
May	125	9.2
June	131	9.7
July	105	7.7
August	80	5.9
September	112	8.3
October	112	8.3
November	112	8.3
December	121	8.9

TABLE 3 Selected Characteristics Associated With ASSB Death According to Text From the Cause-of-Death Section of the Death Certificate (Causes of Death and the Description of How the Injury Occurred) as Entered by the Death Certificate Certifier, United States, 2003–2004

Characteristic	*n*	%
Mechanism attributable to suffocation		
Overlay	315	33.8
Suffocation by bedding/soft materials on sleep surface	128	13.7
Wedging/entrapment between 2 objects (eg, bed, wall)	132	14.2
Face down or obstructed position	24	2.6
Other (car seat, strangulation)	4	0.4
Unknown/could not be determined	214	23.0
Pending[a]	114	12.2
Sleep surface or place where death occurred		
Bed	256	27.5
Crib	63	6.8
Sofa/couch/recliner	93	10.0
Other (bean bag, chair, car seat, playpen)	10	1.1
Unknown/could not be determined	397	42.6
Pending	112	12.0
Cosleeping/bed sharing reported		
Yes	456	51.2
No	56	6.3
Unknown/could not be determined	266	29.9
Pending	113	12.7

[a] Cause of death was still pending investigation when the NCHS statistical file was closed and cause of death was classified according to preliminary findings.

the circumstances could not be ascertained from the data provided in 35.1% of the cases. Beds, cribs, and couches were reported as the most common sleep surfaces where ASSB deaths occurred. Of the 931 ASSB deaths during 2003 and 2004, 27.5% were reported as occurring in adult beds, 6.8% in cribs, 10.0% on sofas or couches, and 1.1% in other places (n = 10, including car seats, bean bags, playpens, and cars). No mention of sleep surface was made in 54.6% of all death certificates. Cosleeping or bed sharing was reported in 53.3% of the cases.

DISCUSSION

Infant mortality rates attributable to ASSB have quadrupled in the last 2 decades, with the most dramatic increase occurring after 1996. Although the overall SUID rate showed no important increasing or decreasing trend from 1998 through 2004, the trend showed signs of a potential decline after 2003. The pattern observed for the other SUID-specific causes of death during this time did reveal an increasing trend for ASSB and cause unknown and a declining trend for SIDS. Death rates for total SUID and each SUID-specific cause of death declined in 2003, with all but cause unknown increasing again in 2004. It is unknown whether this trend is significant, because this dip in rates seems anomalous. Only additional years of data will allow us to determine whether this represents a changing trend in SIDS and total SUID, or whether the dip in rates is because of unstable estimates.

With some promise of a declining total SUID rate form the latest years of data available, during 2001–2004, the proportion of SUID deaths attributed to ASSB continued to increase, whereas the proportion of deaths attributable to SIDS remained stable and the proportion attributable to unknown cause declined. Black male infants are disproportionately affected by ASSB, and infant mortality attributable to ASSB is highest among infants 0 to 3 months of age; most cases occur at 1 month of age. ASSB deaths occurred more frequently in the earlier half of the week (Sunday through Wednesday) compared with the later half (Thursday through Saturday). Factors contributing to ASSB deaths could be determined in about two thirds of all ASSB cases; overlaying was the most frequently reported contributing factor. Cribs, adult beds, sofas, and other sleep surfaces were implicated in ASSB infant deaths, but >50% of the cases did report data about the sleep surface.

The impressive decline in SIDS during the 1990s has been credited to national efforts promoting a supine sleep position for infants.[15,16] Yet since 1998, safe-sleep

prevention efforts may have had little effect in reducing total SUID deaths overall. Instead, the relatively stagnant total SUID rate together with the observation that declining SIDS rates are being offset by increasing ASSB and unknown cause rates suggests that the way these deaths are classified has changed. This change in classification and reporting has been observed in recent studies.[1,8]

One explanation for this diagnostic change may be stricter adherence to the 1991 SIDS definition,[17] ie, unexplained deaths that lack a thorough case investigation cannot be classified as SIDS, and thus are classified as cause unknown. Also, the requirement of a thorough death-scene investigation for a SIDS diagnosis could have lead to more accurate cause-of-death classification and explain why the total SUID mortality rate has remained stagnant, whereas the proportion of ASSB and cause unknown deaths among total SUID deaths have been increasing and SIDS deaths have been decreasing. Similarly, the use of CDC's 1996 death-scene investigation guidelines and SUIDIRF[9] by many jurisdictions may explain why deaths are being classified as ASSB more often. However, CDC's renewed efforts to teach and encourage the use of standard approaches for infant scene investigation predate this current analysis's study period (see www.cdc.gov/SIDS/SUID.htm).

The increase in local and state child death teams that review SUID cases may also be contributing to improved understanding of SUID deaths. Child death review teams often request comprehensive death-scene investigation evidence in an effort to improve prevention efforts and some can influence cause-of-death classification.[18] It is also possible that changes in classification may reflect diagnostic preferences of certifiers.[3,8] Guidance about classifying SUID deaths, although offering different perspectives, have recently been published.[19,20]

This study has several strengths. To our knowledge, it is the first study to document the national trend showing a fourfold increase in ASSB infant mortality in recent years. In addition, the analysis examines all infant mortality, not just postneonatal mortality, an important factor because 15% of all ASSB deaths occur during the first month of life. Additional study strengths include its US population base and the many years of data available for analysis.

The study also has some limitations. First, because we relied on death certificate data, cause-of-death reporting practices may be inconsistent between medical certifiers. Second, we were limited to the variables recorded on the death certificate and did not have more detailed data such as investigation reporting forms and autopsy reports.

In respect to the subanalysis of the written textual information on the death certificate, observations provided some insight about the circumstances contributing to these deaths. Although this subanalysis is an important strength, we were limited by incomplete textual information for nearly half of the cases and lack of knowledge about certifier reporting practices. Some of the incomplete information resulted from cases where the text indicated that a cause of death was still pending investigation when the NCHS statistical file was closed.

Finally, because ours is a descriptive study, there is no comparison group, and we do not assess risk factors related to ASSB. A national SUID surveillance system that captures standardized and consistent information from the death-scene investigation and autopsy would provide valuable information for future studies and could better inform prevention activities. Having complete data from infant death-scene investigations not only is critical for accurate and consistent classification of cause of death, but also importantly informs our understanding about the circumstances in which ASSB and other SUID deaths occur.

CONCLUSIONS

Infant mortality rates attributable to ASSB have quadrupled in the last 2 decades, with the most dramatic increase in rates occurring after 1996. The reason for the increase is unknown, but black male infants <4 months of age are disproportionately affected. Prevention efforts should target those at highest risk and focus on helping caregivers provide safer sleep environments. Increased and understanding of the specific circumstances of sleep environments associated with ASSB deaths may help researchers determine why recent safe-sleep promotion efforts have resulted in a reduction in SIDS, but not ASSB deaths.

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TEXTING SHOWS RECOVERY AFTER FAINT

"Festival Medical Services . . . provides music festivals throughout the United Kingdom with doctors, nurses, paramedics, first aiders, and other trained medical and administrative staff. This team provides a resuscitation facility for the audience at the 2 main stages at Glastonbury and Reading festivals as well as a triage system to sort or treat people who need medical attention. Three years ago we noticed that most of the patients with faint or panic attack were teenagers and as soon as they could they used their mobile phones to send an SMS (short message service) text message to their friends. SMS allows the interchange of short text messages between mobile phones. About 1.4 billion text messages are sent in the UK alone every week, according to the Mobile Data Association (www.text.it). The ability to text, whether or not it actually makes sense, requires a Glasgow coma scale score of 15 (fully conscious), an adequately functioning 'executive system' in the frontal lobes, and a high degree of manual dexterity and psychomotor coordination. It also shows a degree of common sense not always evident in teenagers. Two years ago we decided to use this texting sign as an indication that patients had recovered from their faint or panic attack and were orientated and coordinated enough to be discharged back to the festival. At times of massive influx to the medical tent, when up to 2 patients a minute are triaged, this system seems to work well. The texting sign needs further investigation to determine whether it is a valid criterion for recovery after faint or panic attack at festivals as well as in busy accident and emergency departments."

Sinclair M, Pigott, D, Carpenter KN. *BMJ* 2008;337:a2723. December 17, 2008
Noted by LRF, MD

US Infant Mortality Trends Attributable to Accidental Suffocation and Strangulation in Bed From 1984 Through 2004: Are Rates Increasing?

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